Description of the Prior Art

Known microphones of this type are usually supplied with power via a connecting line or a cable, respectively, via which the electrical signals are transmitted to the receiving unit, or have active electronic components and their own power supply in the form of a battery. Microphones in which the electrical signals are transmitted to a receiving unit via a wireless type of transmission, for example radio microphones, must have their own battery or their own accumulator which provides the necessary power for signal processing and signal transmission.

The receiving unit is, for example, a telephone base station which is connected to a landline network, but can also be a mobile station of a wireless telecommunication system. If the microphone is integrated in a headset, a cable link between the headset and the telephone base station is disadvantageous in many applications due to the restriction of the freedom of movement. In the German Patent Document No. 195 20 674, it is proposed to send signals of a piezoelectric sensor to an evaluating device. In this case, however, it must be assumed that the transmitter has its own power supply. However, providing the microphone of the headset with its own power supply in the form of a battery is too much to ask of a user because of the increase in weight.

In hands-free systems in motor vehicles, for example, neither of the two known solutions is practicable because, on the one hand, a cable link between microphone and telephone restricts the freedom of movement and vision of the driver and, on the other hand, prolonged wearing of a heavy microphone can be disturbing when driving a car.

Further, the microphone of a hands-free system in a motor vehicle should be as close to the mouth of the speaker as possible in order to keep the level of disturbances caused by loud driving noises as low as possible. In the Swiss Patent Document No. CH 664 659, a throat microphone is disclosed which is effectively partitioned off against the effects of external sound. The resonator of the throat microphone is formed by piezoelectric materials. The voltages occurring across the piezoelectric material due to sound vibrations are picked up and sent to a transmission unit either by wire or wirelessly. The disadvantageous factors in this implementation are mainly two things: on the one hand, it is generally more difficult to amplify the

human voice by means of the sounds formed in the throat than the spoken word. In the case of a wireless transmission of the low-frequency voice signals, on the other hand, the problems would occur which usually occur in the case of unmodulated signals. As an example, propagation characteristics or bandwidths are only mentioned here. If a modulated signal is to be used, the throat microphone would need its own power supply which would necessarily lead to disadvantages of using same due to, for example, increased weight as mentioned above.

An object of the present invention, therefore, is to provide a microphone for transmitting sound information to a receiving unit, which microphone is constructed in a simple and lightweight manner and, at the same time, provides for the wireless transmission of the sound information to the receiving unit.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a passive microphone for wirelessly transmitting sound information to a receiving unit, which has a piezoelectric device for receiving and storing excitation energy from the receiving unit and for wirelessly transmitting electrical signals, converted from detected acoustic signals, to the receiving unit.

Using a piezoelectric device makes it possible, on the one hand, to receive and store excitation energy from the receiving unit and, on the other hand, to wirelessly transmit electrical signals bearing sound information to the receiving unit, thus providing a simple and lightweight construction of the microphone. Further, by storing excitation energy in the piezoelectric device, it is not necessary for the microphone to have its own power supply in the form of a battery or an accumulator.

The microphone of the present invention is a passive microphone, i.e., it is not provided with its own power supply and the transmission of electrical signals bearing sound information from the microphone to the receiving unit is carried out via continuous or discontinuous power transmission in the form of an electromagnetic signal via the receiving unit. The microphone of the present invention is, thus, constructed in a lightweight and simple manner and capable of effectively providing wireless transmission of electrical signals.

The piezoelectric device stores the excitation energy from the receiving unit in the form of mechanical vibrations. Furthermore, a particularly lightweight and simple construction can be achieved if the piezoelectric device is used, at the same time, for storing the electromagnetic excitation energy, for detecting acoustic signals and for converting detected acoustic signals into electrical signals bearing sound information. In this case, the passive microphone of the present invention which includes the piezoelectric device can result in a particularly simple, lightweight and inexpensive construction.

The piezoelectric device can include, for example, a piezoelectric diaphragm. The excitation energy from the receiving unit can then be absorbed via the antenna of the microphone and converted into mechanical vibrations of the diaphragm. At the same time, the vibrating diaphragm can detect acoustic signals which are also modulated as mechanical vibrations onto the vibrations of the diaphragm caused by the excitation energy. The modulated vibrations are converted into electrical signals by the piezoelectric diaphragm and transmitted to the receiving unit. The piezoelectric diaphragm can be composed of, for example, a crystal or lithiumniobate. Crystal, in particular, has a very high Q factor as energy store.

As an alternative to the piezoelectric diaphragm, the piezoelectric device can include a surface acoustic wave delay line, a resonator or the like. In these embodiments, too, a single device is, thus, used for storing the electromagnetic excitation energy, for detecting acoustic signals and for converting detected acoustic signals into electrical signals bearing sound information, as a result of which a simple construction is possible.

As an alternative to constructing the piezoelectric device essentially of a single element, the piezoelectric device can comprise a device for detecting acoustic signals and a device for storing the electromagnetic excitation energy and for converting detected acoustic signals into electrical signals bearing sound information. Separating the functions into two different elements makes it possible to achieve greater sensitivity and better transmission quality. The device for detecting the acoustic signals can include, for example, a diaphragm, preferably composed of metal. The

device for storing the electromagnetic excitation energy and for converting detected acoustic signals into electrical signals including sound information preferably includes a piezoelectric element such as, for example, a surface acoustic wave delay line or a resonator such as, for example, a piezoelectric diaphragm. The diaphragm for detecting acoustic signals can be bonded, for example, to the piezoelectric element, such as to the surface acoustic wave delay line or to the resonator, in order to be able to modulate the detected sound signals converted into mechanical vibrations directly onto the vibrations in the piezoelectric element which are caused by the excitation energy of the receiving unit. The modulated vibrations are then converted into electrical signals by the piezoelectric element and are transmitted to the receiving unit.

It is preferable in the two embodiments described above that one or a further device for detecting acoustic signals is provided and is arranged in such a manner that the detected acoustic signals are differentially converted into electrical signals bearing sound information. As a result, the sensitivity of the microphone of the present invention can be considerably enhanced. Furthermore, it is preferable that a device for compensating for disturbance variables is provided in order to compensate, for example, for the influence of temperature fluctuations or the like.

The electromagnetic excitation energy from the receiving unit can be transmitted to the piezoelectric device of the microphone of the present invention in the form of discontinuous or continuous excitation signals. The piezoelectric device can be designed in such a manner that it receives the electromagnetic excitation energy from the receiving unit in the form of short high-frequency signals. The electromagnetic excitation signals from the receiving unit can also be periodically repeated high-frequency signals. It is preferable that the piezoelectric device receives the electromagnetic excitation energy from the receiving unit in the form of excitation signals having a large bandwidth-time product. As an alternative, the piezoelectric device can receive the magnetic excitation energy from the receiving unit in the form of a continuous frequency-modulated excitation signal.

Additional features and advantages of the present invention are described in, and will be apparent from, the Detailed Description of the Preferred Embodiment and the Drawings.

DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a diagrammatic representation of a microphone of the present invention and an associated receiving unit; and

Fig. 2 shows an embodiment of a piezoelectric device of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 diagrammatically shows a passive microphone 1 of the present invention and a corresponding receiving unit 6. The passive microphone 1 of the present invention includes a piezoelectric device 4 for receiving and storing excitation energy from the receiving unit 6 and for wirelessly transmitting electrical signals converted from the detected acoustic signals to the receiving unit 6.

In the preferred embodiment as shown in Fig. 1, the piezoelectric device includes a device 2 for detecting acoustic signals and a device 3 for converting the detected acoustic signals into electrical signals bearing sound information. The microphone 1 also includes an antenna 5, connected to the piezoelectric device 4, for receiving the excitation energy from the receiving unit 6 and for sending out the electrical signals bearing sound information to the receiving unit 6.

The receiving unit 6 also includes an antenna 7 for sending out the excitation energy in the form of excitation signals and for receiving the electrical signals from the microphone 1.

As is shown in Fig. 1, the receiving unit 6 transmits the excitation energy, for example in the form of discontinuous excitation pulses, to the microphone 1. The excitation pulses are received by the piezoelectric device 4 of the microphone 1 via the antenna 5 and are stored, e.g., as mechanical vibrations. For this purpose, the piezoelectric device 4 includes, for example, a piezoelectric element as is shown in Fig. 2. The piezoelectric element includes a piezoelectric diaphragm 8 on which, for example, reflectors 10 composed of deposited metal strips are provided.

Furthermore, a converter 9, which is coupled to the antenna 5, for converting the received excitation pulses into a surface acoustic wave is provided on the diaphragm 8. The converter 9 is connected to a ground. Similar to the reflectors 10, the converter 9 includes metal patterns, e.g., of aluminum, applied to the diaphragm 8.

When a high-frequency excitation is received from the receiving unit 6, the diaphragm is excited into vibrations via the converter 9 due to the formation of a surface acoustic wave. The vibrations expand on the top of the diaphragm in both directions toward the reflector fields 10 and are reflected by these so that a standing wave is formed in the case of resonance. In this manner, the excitation energy of the excitation pulse from the receiving unit 6 is stored in the form of mechanical vibrations. The piezoelectric element reflects the energy temporarily stored as mechanical vibrations back to the receiving unit 6 in the form of a decaying vibration via the antenna 5 as shown diagrammatically in Fig. 1. This decaying vibration is received in the receiving unit 6 via the antenna 7, and is detected, demodulated and analyzed.

The resonant frequency of the piezoelectric element and thus of the decaying vibration, which is reflected back to the receiving unit 6 by the piezoelectric element, changes under the influence of a strain because the speed of propagation of the surface acoustic wave and the distances between the two electrodes of the converter 9 change. In the embodiment shown in Fig. 1, the diaphragm 8 with the reflectors 10 is used as the device 3 for storing excitation energy from the receiving unit 6 and for converting the detected acoustic signals into electrical signals bearing sound information. The device 2 for detecting acoustic signals can be formed, for example, by a diaphragm, not shown, preferably composed of metal, which is bonded to the diaphragm 8. The diaphragm used as the detection device 2 absorbs sound waves and converts them into mechanical vibrations. The mechanical vibrations are transferred from the diaphragm detecting the acoustic signals to the piezoelectric diaphragm 8. In this process, corresponding vibrations of the vibration of the piezoelectric diaphragm 8 caused by the electromagnetic excitation from the receiving unit 6 are modulated onto the acoustic

signals. The modulated vibration is converted back into electrical signals via the converter 9 and transmitted as electromagnetic signal back to the receiving unit 6 via the antenna 5.

As an alternative to the piezoelectric diaphragm 8 with the reflectors 10 and the converter 9, shown in Fig. 2, a surface acoustic wave delay line can be used as the device 3 for storing electromagnetic excitation energy from the receiving unit 6 and for converting the detected acoustic signals into electrical signals bearing sound information. In a surface acoustic wave delay line, electromagnetic excitation energy from the receiving unit 6 is also stored as mechanical vibration. A detection device 2 for detecting acoustic signals, which is coupled to the surface acoustic wave delay line, converts received acoustic signals, i.e., sound waves, into mechanical vibrations which are transferred to the surface acoustic wave delay line. This causes transit-time effects in the mechanical vibration caused by the excitation energy from the receiving unit 6, as a result of which the acoustic signals are modulated onto this mechanical vibration.

The acoustic signals detected by the device 2 are thus converted into electrical signals bearing sound information by the device 3 and modulated onto the piezoelectric element so that the decaying harmonic vibration reflected back bears the sound information modulated on. This sound information modulated on can be detected and analyzed in the receiving unit 6.

It is preferred that the piezoelectric device 4 combines the devices 2 and 3 in one element which both detects the acoustic signals and also converts the detected acoustic signals into electrical signals bearing sound information. The piezoelectric diaphragm 8 with the surface acoustic wave resonance pattern, shown in Fig. 2, is used as the single element forming the device 4. In this case, the piezoelectric diaphragm 8 detects incoming acoustic signals in the manner of a pressure sensor. The standing wave in the piezoelectric element, which is excited by an excitation pulse from the receiving unit 6, is modulated by the acoustic signals so that the decaying vibration reflected back to the receiving unit 6 after the end of the excitation pulse includes the corresponding sound information. This makes it possible to provide a very durable

passive microphone for wireless transmission of sound information which has a simple and lightweight construction.

The microphone 1 of the present invention can be constructed as a passive component, i.e., without its own power supply in the form of a battery or the like, since the energy of the excitation pulses from the receiving unit 6 absorbed by the piezoelectric element, can be stored and used for transmitting the sound information.

To avoid heterodyning of the excitation signals with the signals bearing the sound information, transmitted by the microphone 1, the piezoelectric element can be excited discontinuously, for example by a pulsed excitation signal. However, it is also possible to utilize certain continuous excitation signals. An impulse response in the form of a decaying vibration, which is extended over a very long period in the time domain, is generated, and transmitted back to the receiving unit 6, in particular, if the diaphragm 8 is a crystal diaphragm which has a very high Q factor.

Furthermore, the piezoelectric diaphragm 8 can be composed of lithiumniobate.

Instead of the piezoelectric diaphragm 8 with the surface acoustic wave resonant pattern, shown in Fig. 2, a surface acoustic wave delay line can also be used as the single element of the device 4. The surface acoustic wave delay line can both detect the acoustic signals and convert the detected acoustic signals into electrical signals bearing sound information.

If the piezoelectric device 4 is used for detecting the acoustic signals, a second piezoelectric device can be provided in order to provide for differential processing and conversion of the detected acoustic signals and thus to increase the sensitivity, for example for compensating for temperature fluctuations. If a separate device 2 for detecting acoustic signals is provided, a second device 2 for detecting acoustic signals can be provided in order to provide for differential conversion of the detected acoustic signals into electrical signals for the same purpose. In addition or as an alternative, a device for compensating for further disturbance variables can also be present.

As is shown diagrammatically in Fig. 1, the electromagnetic excitation energy can include discontinuous excitation pulses which are sent out by the receiving unit 6

and are correspondingly received by the microphone 1 of the present invention. The excitation pulses from the receiving unit 6 can be, for example, short high-frequency signals which, if necessary, are periodically repeated. It is preferred in this arrangement that the excitation signal from the receiving unit 6 has a large bandwidth-time product. In an embodiment, continuous frequency-modulated excitation signals can be used.

Since the passive microphone 1 of the present invention is constructed in a very lightweight and durable manner, it can be attached, for example, to a

spectacles frame. The antenna 5 of the microphone 1 can be formed, for example, by one of the earpieces of the spectacles or by the frame of one of the spectacle lenses. The microphone can be attached, for example, to the transition between the earpiece, used as antenna, and the spectacle lens frame.

As an alternative, the microphone of the present invention can be attached to a holder which is detachably attached to the spectacle frame and which can extend downward in the direction of the mouth of the wearer from the spectacle lens frame. In this case, the holder can be constructed as the antenna 5 of the microphone 1.

The passive microphone 1 of the present invention can also be suitable for use in a wireless headset such that voice signals can be transmitted to a telephone base station or a telephone mobile station. The microphone of the present invention can be constructed to be very lightweight and rugged which results in varied and specialized applications.

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

ABSTRACT OF THE DISCLOSURE

The present invention relates to a passive microphone for wirelessly transmitting sound information to a receiving unit. The passive microphone includes a piezoelectric device for receiving and storing excitation energy from the receiving unit and for wirelessly transmitting electrical signals, converted from detected acoustic

signals, to the receiving unit. The passive microphone, i.e., without its own power supply, provides for a lightweight and, at the same time, rugged and durable construction which can be utilized in a variety of different applications, particularly in telephone applications.